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A Study Of Worldwide Patent Strength Of Competitors On Autonomous Parking

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Abstract— A study of worldwide patent strength and patent comprehensive of competitors based on patent maps are presented in this paper. A worldwide completed, commercialized, and ongoing technology, autonomous parking, was selected to demonstrate the analysis. Analysis results show on three 2D patent strength maps, including valid patent strength based on citations and valid patent percentage, technology comprehensive strength based on technology-function comprehensive and technical broadness, geographical coverage strength based on members of a patent family and geographical breadth.

Patent pool in this study are from official database by USPTO, EPO, JPO, CHIPA, and WIPO. Inventive activities of top twenty companies are shown year by year in the form of patent families. Technologies and functions are manually classified to get technical strength for R&D perspective. Top ten competitors are analyzed on patent strength maps, the result shows that BOSCH and TOYOTA takes the lead in all patent strength evaluation.

Keywords— patent strength; patent map; patent comprehensive; autonomous parking

I. INTRODUCTION

Autonomous driving is a hot technology that has continued to develop for more than a decade in the world. National Highway Traffic Safety Administration in the United States proposed five levels of auto-driving. Level 1 is driver assistance, lever 2 is partial automation, level 3 is conditional automation, level 4 is high automation, and level 5 is full automation. Woodside Capital Partners in its report estimated that the level of autonomous driving pursued by various manufacturers will gradually promote, and it is estimated that by 2030, level 5 autonomous vehicles can be fully reached.

Parking assistance systems have been developed earlier and faster in the entire advanced driving assistance system. Some vehicles have been fulfilled automatic parking without even manual control. For example, TOYOTA was first realized in the “Prius” car model in 2003, the system is mainly used by the driver to select a parking space through the image and submit it to the system performs steering wheel steering control. In 2008, Valeo used Volkswagen vehicle to detect and locate the parking space through the ultrasonic sensor, which greatly shortened the parking time within 50 seconds. This system was also implemented in Mercedes Benz models. In 2015, many car manufacturers successively announced automatic parking systems. As long as the driver told the vehicle to enter the parking procedure, the vehicle would find a parking space and park in the parking grid. Until recent years, the function of remote parking has even emerged. The driver can get out of the car and operate the controller, allowing the vehicle to complete the parking following instructions.

A study of worldwide patent strength of competitors on auto-parking will be presented in this paper. The number of patent citations is most often used to evaluate the strength or quality of a patent. The basic concept of these study is that the higher number cited by later filing patents, the higher value of the patent. A fundamental patent in a technical field usually has the highest number of citation as prior art by subsequent patents [1].

The size of patent family is another indicator of patent strength, the larger size of family, the higher value of the patent [2][3]. Commercial software can calculate patent strength based on many indicators, such as backward citations, forward citations, patent litigation, family numbers, claim numbers, etc., stakeholders can understand how a particular market or technology stacks up and explores a competitive landscape among top assignees [4]. For technical developer, technology-function analysis is very useful to visualize patent comprehensive of competitors, and a patent strength indicator could be calculated by the technology-function matrix [5][6].

An analysis of international patent strength shown on patent maps will be presented in this study. The map is a coordinate map composed of two patent strength indicators. We made patent search in the official databases, The United States of Patent and Trademark Office(USPTO), European Patent Office (EPO), Japan Patent Office (JPO), China Patent Office (National Intellectual Property Administration, PRC., CHIPA), which are the most four important national patent offices, because they grant patents cover big market. Patent Applications are through Patent

Cooperation Treaty (PCT) system also included, the system managed by World Intellectual Property Organization (WIPO), consolidates one application beginning at international phase, and then enters national phase or regional phase to get more national patents.

II. METHODOLOGY AND DATA

The first patent pool in this study was gotten from official databases by organized search queries as shown in Table 1. Different databases offer different types of search interface. We utilized patent classification and key words and made the pools consistent as could as possible. We can get the first patent pool is publication documents in the five offices, many of them are one invention file to more than one office.

Table 1 Search queries and the numbers of documents

database	Search query	Documents
USPTO	(ICL/B62D15/02 or ICL/B60W30/06) and spec/parking$ and PD/20080101->20181116	654
JPO	IPC including B62D15/02 or B60W30/06 Detailed description including 駐車 PD:20080101~20181116	524
EPO	(IPC=B62D001502 or IPC=B60W003006) and (dede=parken or dede=anhalten or dede=parking or dede=stoppen or deen=parking or defr=garer or defr=stationnenment or defr=parking) and PUD[20080101, 20181116]	392
CNIPA	IPC:B62D15/02 or ICL/B60W30/06 SPEC:停车 PUD:20080101-20181116	746
WIPO	IC_EX:(B62D15/02 or B60W30/06) and DP:[01.01.2008 TO 16.11.2018] and DE:(parking or parken or anhalten or stoppen or garer or stationnenment or 停車 or 停车 or 駐車)	412

We selected top 15 applicants in the USPTO and top 10 applicants in the other four patent offices, and manually screen out low related documents to be the second pool, which consists of 250 documents in the US, 189 in EP, 210 in JP, 246 in CN, and 241 in PCT. Deleting low-associated documents ensures correct results.

We classified the second pool into six technical classes manually. Class A is main control refers to the actions that control the vehicle itself to perform instructions. Class B is environmental sensing, vehicle's own sensors to detect parking spaces and obstacles. Class C is auxiliary control, refers to parking using auxiliary equipment outside the vehicle, such as remote equipment control. Class D is parking lot control, it means that the vehicle is inside the parking lot, obtains the parking space, arrives at the parking space by self-driving, or controls the vehicle parking by the parking lot. Class E is parking method, the vehicle starts from the parking preparation position, and automatically enters the parking space by self-driving. And class F is others, including vehicle pickup, parking correction, vehicle exit, charging, etc. The reason of manual classification instead of Cooperative Patent Classification is that it is more consistent of the perspective of researchers.

III. ILLUSTRATION

A. Patent applications in five patent offices

Fig.1 is patent application trend chart in five patent offices based on the first pool. The overall trend can be divided into three stages. The first stage is from 2000 to 2007, which is the germination stage of technology, applications filed in Europe as early as 2000. The second stage is from 2008 to 2013, which is a steady growth period. The third stage is rapid growth period since 2014. The number of applications has massive growth year by year. Especially in the United States and China, the number of applications has increased by about 30% each year. The numbers of 2017 and 2018 are not full because of 6 to 18 months delay from filing to publication, it will be reasonably expected that more applications than the past.

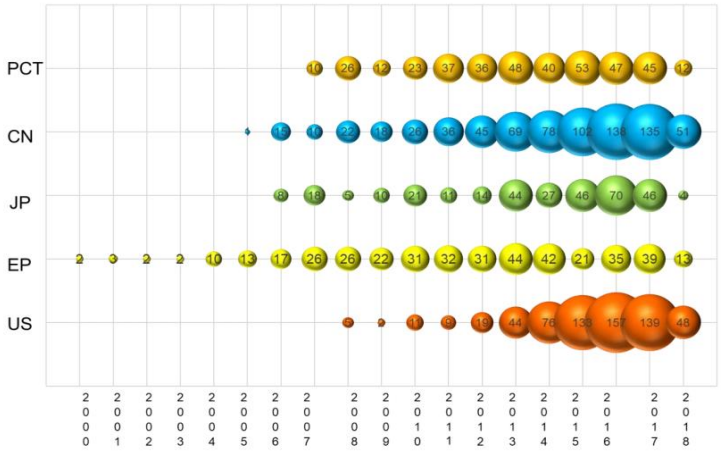

Fig.1 Patent application trend in five offices

European patent applications have developed earlier than other regions. Although there is no sudden and large increase in the number of patents, it can be said that the number of patents that maintains stability every year is developing. The latest application is the

United States since 2008, but in recent years, it has the highest growth rate and the most applications.

The industrial development situation in China is similar to the U.S., Japan patent applications started as early as 2006, and the largest number of applications fell between 2013 and 2017. PCT applications have generally remained stable in the past decade.

B. Patent applications of main applicants

Fig. 2 is a patent application trend chart of top 20 applicants based on priority year. The numbers in bubbles are patent families, which means the numbers of inventions. Priority year is close to the year of invention completion. We collected 875 global patent families in total based on the first patent pool.

Bosch is the top one applicant, with 165 inventions, leads the second position Aisin more than twice. Bosch, Aisin, Valeo, and Toyota are all leaders who have invested more than 10 years and are constantly developing. Ford, Hyundai, and Mitsubishi produced more inventions after 2015.

It is interesting that three companies have made a lot of inventions in a particular year, Nissan in 2012, Renault in 2016, and Hitachi in 2015. They invest a lot of R&D resources in a year to produce a lot of inventions, could catch up with technology leaders in a short time.

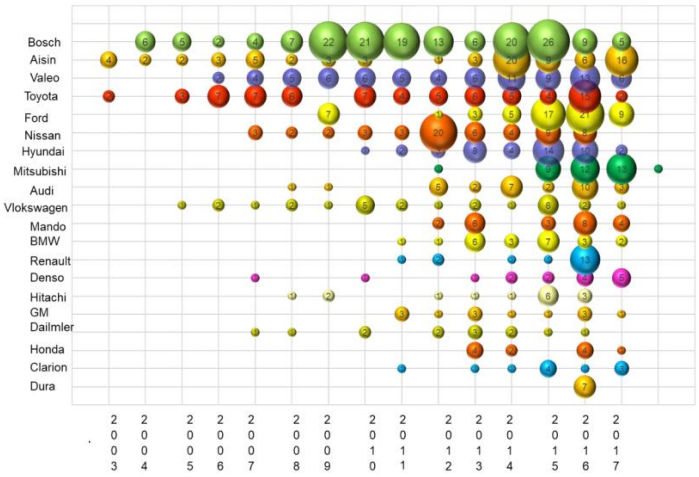

Fig.2 Inventive activities of main applicants

C. Activities of main applicants in five offices

Fig.3 is main applicants on technical classifications in the USPTO. It shows main control (class A) and sensing (class B) are core technologies in auto-parking, every applicants own patents in these two classes. Auxiliary control, such as remote equipment control (class C) is gradually being values since the popularity of smart phones. Bosch is the applicant who values parking lot control most.

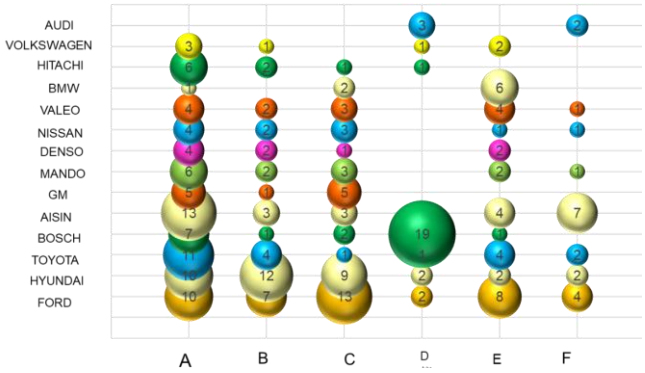

Fig.3 main applicants on technical classifications in USPTO

Fig.4 is main applicants on technical classifications in EPO. The number of patent application is less than USPTO because patent fees are expansive, even for big vehicle company. Five applicants own complete technology category. Two of them are home in Europe, BOSCH is a global vehicle company, and VALEO is a global automotive supplier. The other three are Japanese applicants, NISSAN and TOYOTA are vehicle manufactures, AISIN is an auto parts supplier.

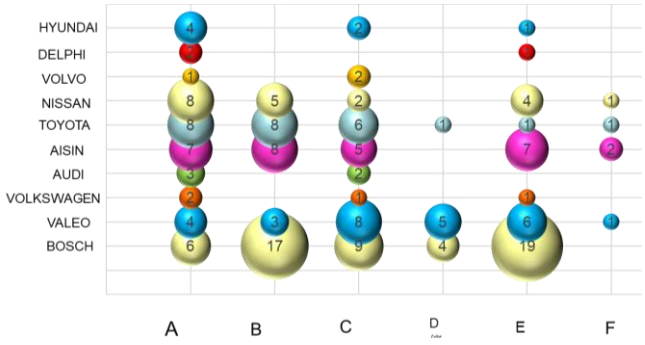

Fig.4 main applicants on technical classifications in EPO

Fig. 5 is main applicants on technical classifications in JPO. Three top Japanese companies in Europe, NISSAN, TOYOTA, and AISIN are appeared again in the figure. Bosch is the only foreign company, showing that the Japanese market is relatively closed and is not values by foreigners.

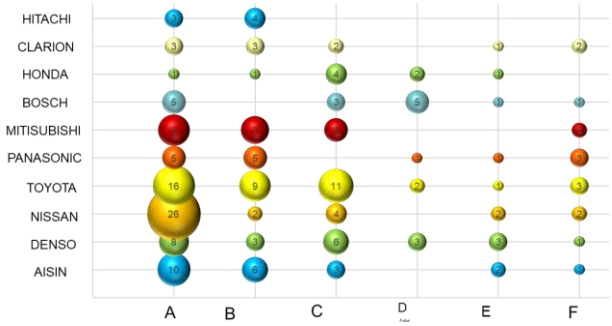

Fig.5 main applicants on technical classifications in JPO

Fig. 6 is main applicants on technical classifications in CHIPA. It can be observed that all main applicants are foreign companies. BOSCH, VOLKSWAGEN, BMW, and VALEO are all from Europe, TOYOTA, NISAN, and AISIN are from Japan, MANDO and HYUNDAI are from South Korea. FORD, a US vehicle manufacturer, who is not shown in EPO and JPO, shows that overseas markets focus on China.

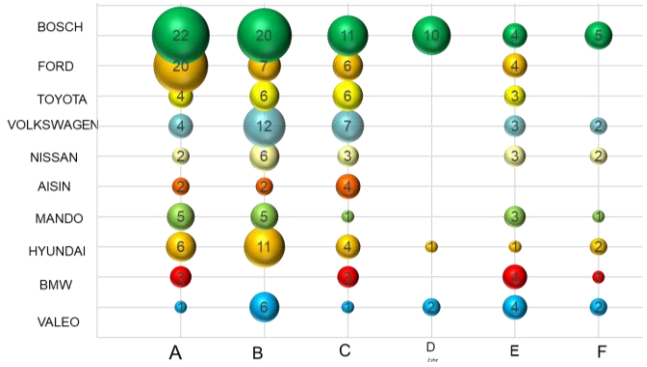

Fig.6 main applicants on technical classifications in CHIPA

Fig. 7 is main applicants on technical classifications in WIPO. PCT route can obtain patents in more than 100 countries. The applicants like to utilize PCT system represents the importance of markets outside of the US, Japan, Europe, and China. In WIPO's annual report, U.S. applicants are the largest users of the PCT system, but not in auto-parking. FORD and GM are not main applicants in Fig.7. They are interested in the U.S. and China only.

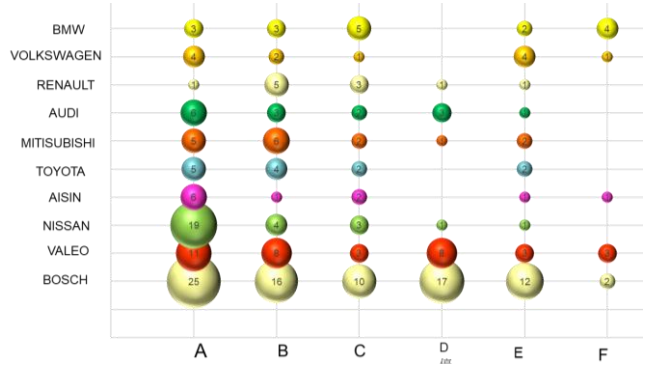

Fig.7 main applicants on technical classifications in WIPO

IV. PATENT STRENGTH OF TOP TEN COMPETITORS

We select ten competitors from main applicants to study their patent strength and show it on 2D coordinate chart.

A. Valid patent strength

Fig. 8 is a patent strength map based on average cited numbers and valid patent percentage. The average cited numbers is total citations divided by patents in the U.S., valid patent percentage is issue numbers divided publication numbers. The size of bubbles proportional to inventions or patent families.

It is observed that VALEO has the highest average cited numbers but the lowest valid patent percentage. GM and BOSCH have high average cited numbers between 4 and 5, GM has higher valid percentage than BOSCH, but patent families are quite opposite. MANDO has the lowest average cited numbers and low valid percentage. FORD, NISSAN, TOYOTA, AISIN, and HYUNDAI are in a close group and similar patent families. The valid patent percentage is not equal to the grant ration, because the denominator is publications which may be still pending.

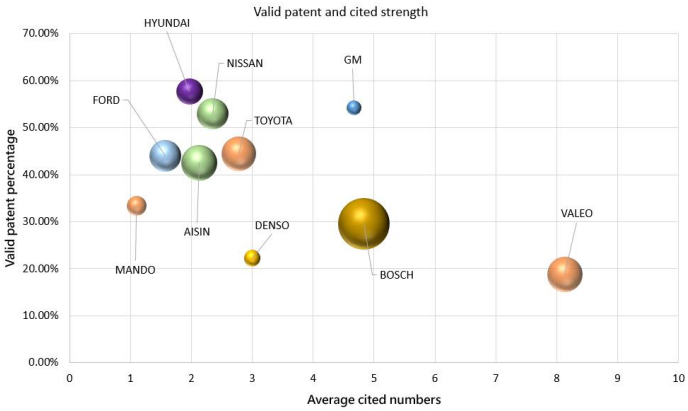

Fig.8 valid patent and cited strength of competitors

Differences in parking spaces in different countries may cause differences in automatic parking technology. For example, American parking spaces are large and private parking spaces are common, automatic parking technology developed in the environment is relatively unique, citations are not very high for FORD and GM, because of fewer cited by others.

B. Tehcnology broadness strength

Fig.9 is a patent strength map based on technical broadness and technology-function comprehensive.

A technology-function matrix is a two dimensional matrix, which using the functions and the technical means to be its two coordinate axes, and drawing each nodes proportional to the number of patents. The matrix are used to calculate technology-function strength but not shown in this paper.

There are three technologies and nine functions in class A. Three technologies are parking control, speed control, and steering control. Nine functions are: executing parking, confirming the actual target space, inputting external parameters, moving path control, adjusting parking speed, setting a speed limit, steering control according to environment, and reduce the number of steer turns, steering control according to tire angle.

Three sensing technologies in class B are camera, supersonic, multi-sensor. Five functions in class B are: to find parking spaces based on space, find parking spaces based on lines, connect private parking spaces, generate parking paths, and avoid obstacles.

Three auxiliary control technologies in class C are guided parking, remote control parking, dynamic parking. Four functions in this class are: automatically go to the parking space, manually select the parking space, determine parking rout, and determine the trajectory and dynamic path.

Two technologies in parking lot class D are central control and parking lot communication. Four functions in this class are: parking lot guidance, automatically move to parking space, parking monitoring, and prepare for parking.

Four parking method technologies in class E are parallel parking, C type parking, forward and backward parking, and multi-type parking. Four functions in this class are: park into a small space, prepare for parking, detect obstacles, and generate a parking trajectory.

Technology-function matrix could be used to show the patent comprehensive or breadth of a company. A company occupies higher percentage of nodes has higher technology-function comprehensive, which is vertical axis of Fig.9. The horizontal axis is the technical broadness, which is the sum of the number percentages in each class.

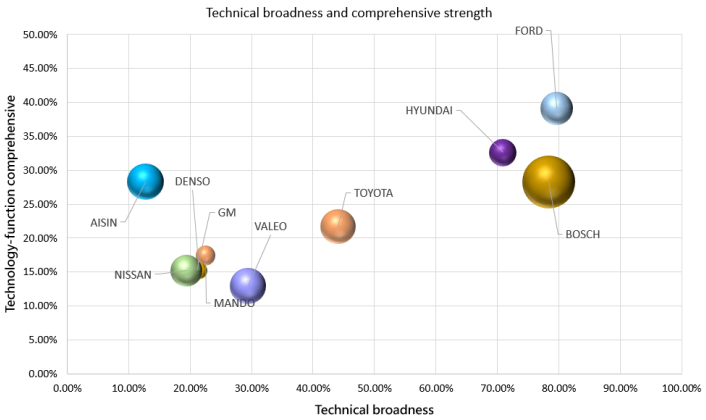

Fig.9 technical broadness and technology-function comprehensive strength of competitors

Three companies are in the leading group, BOSCH, FORD, and HYUNDAI. TOYOTA takes the fourth position. We can say that they want to develop technically and fully functional car models, and be ahead of other companies. All of them are vehicle manufactures.

C. Geographical coverage strength

Fig.10 is a coordinate chart shows geographical coverage strength of competitors. Average members of a patent family means how many patent offices are filed for an invention on the average. Geographical breadth is the sum of the number percentages in each patent office.

It is observed that MANDO has high average members of a patent family but low geographical breadth. BOSCH and TOYOTA are two leaders of high geographical coverage strength. Two American companies, FORD and GM, are mainly interested in the markets of the U.S. and China, FORD has more inventions and cover wider area.

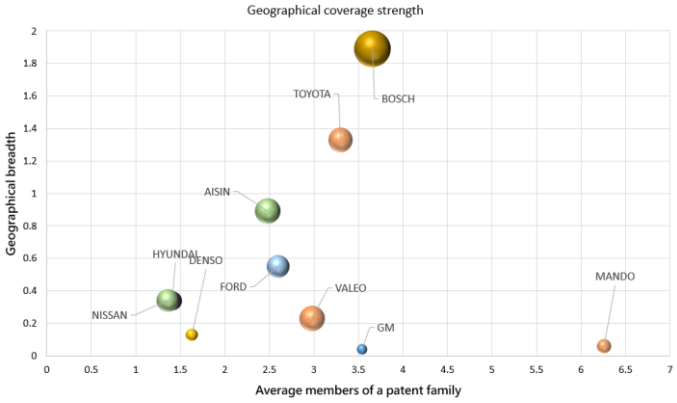

Fig. 10 Technology function matrix of Toyota

V. CONCLUSIONS

Automatic parking is the earliest completed project for autonomous vehicles. The process from the preparation position to the parking of the vehicle has realized the level 5 self-driving vehicle. More and more models have the function of automatic parking. It can be expected that vehicles do not have the function of automatic parking may not be able to obtain good market shares.

After more than ten years of technological development and patent applications. Every vehicle manufactures and parts suppliers have many patents. In this study, three new patent maps represent patent strength of auto-parking for ten competitors, valid patent strength, technology broadness strength, and geographical coverage strength.

BOSCH and TOYOTA are two leading companies in all indicators of patent strength. FORD, who is mainly interested in the U.S. and China market, has high technology broadness but low cited and low geographical coverage. Although HYUNDAI has low number of citations, but high technology broadness, it means the company carried out on its own R&D route and has good achievement.

Auto parts factories also invested in auto-parking development and reached good achievements. Vehicles manufacturers not shown in this paper can cooperate with parts factories to complete auto-parking vehicles.

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